INVESTIGATIONS OF TREE FOLIAGE CONTAMINATION IN THE VICINITY OF CANADA METAL COMPANY LIMITED TORONTO, 1986-1991

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1 INTRODUCTION

1.1 Canada Metal Company Limited: Process

Canada Metal Company Limited (CMC) operates a lead smelting, refining and fabrication facility at 721 Eastern Avenue in Toronto, Ontario. The raw material for these operations is scrap lead, primarily lead from used lead-acid batteries. Whole batteries are not handled at this facility. Batteries are crushed and the lead plates extracted elsewhere.

Scrap lead is fed into a blast furnace, along with coke, limestone and scrap iron. In this environment, lead oxide is reduced to metallic lead, while sulphur from battery acid is trapped by the iron. Two baghouses control particulate emissions from the smelting operation. The trapped dust is fed back into the furnace.

The impure lead is cast into blocks and subjected to refining, alloying or casting or is oxidized to produce lead oxides. Various other baghouses, dust collectors and air filtration systems are used to control dust emissions from these processes as well as losses during bulk truck loading of lead oxide.

The above information was summarized from an environmental audit report prepared by SENES Consultants Limited (Ref. 3) and commissioned by CMC.

1.2 Environmental Monitoring and Remediation

Concern over releases of lead or lead compounds to the environment has prompted continuous monitoring by the Ministry of the Environment (MOE). This monitoring has been conducted primarily by two offices of the MOE: Central Region Abatement East, and Air Resources Branch. The Central Region maintains a network of suspended particulate and dustfall monitors in the vicinity of CMC. The material collected by these monitors is analyzed for lead.

Since 1972, the Phytotoxicology Section, Air Resources Branch has conducted annual collections of tree foliage. These foliar samples were analyzed for lead and other metals. Other Phytotoxicology investigations have included soil collection and analyses and the use of moss bags (Sphagnum moss in nylon mesh bags) as passive accumulators of airborne metals. The most recent report on Phytotoxicology Section investigations near the CMC facility discussed data from 1983, 1984 and 1985 (Ref. 2).

Because of evidence of significant contamination of soil, allegedly caused by emissions from CMC, as well as other urban sources, a large scale soil replacement project was undertaken on residential and public properties in 1987 and 1988.

2 PHYTOTOXICOLOGY INVESTIGATIONS, 1986 THROUGH 1991

This report will present and discuss the results of Phytotoxicology Section investigations conducted in 1986 through 1991. During this period soil sampling was conducted by an environmental consulting company in preparation for the remediation project. Consequently, the Phytotoxicology Section monitored lead and other metal contaminants in tree foliage only.

2.1 CMC Tree Foliage Survey Design

A network of sample trees located within 750 metres of CMC which had been established and sampled prior to 1986, were visited in the month of September of 1986 to 1991 (except 1988). This network is displayed in Figure 1. The majority of these tree foliage collection sites are located on residential properties, usually in front yards, in the neighbourhood immediately north of CMC. Other sites included a park, school and industrial/commercial properties. This area is generally known as 'South Riverdale'.

The tree species used in these surveys differ from site to site. While this feature is not desirable in such surveys, it was necessary due to a lack of one common species throughout the survey area. During the period covered by this report, and prior, it may have been necessary to relocate a sampling site a short distance due to the loss of a sample tree. Occasionally, a different species had to be selected to maintain the integrity of the network, especially as a mechanism to track temporal trends in tree foliage contamination. However, the majority of trees and sites have remained unchanged since 1981. Therefore, this data base is particularly useful for making annual comparisons of the variation in metal deposition.

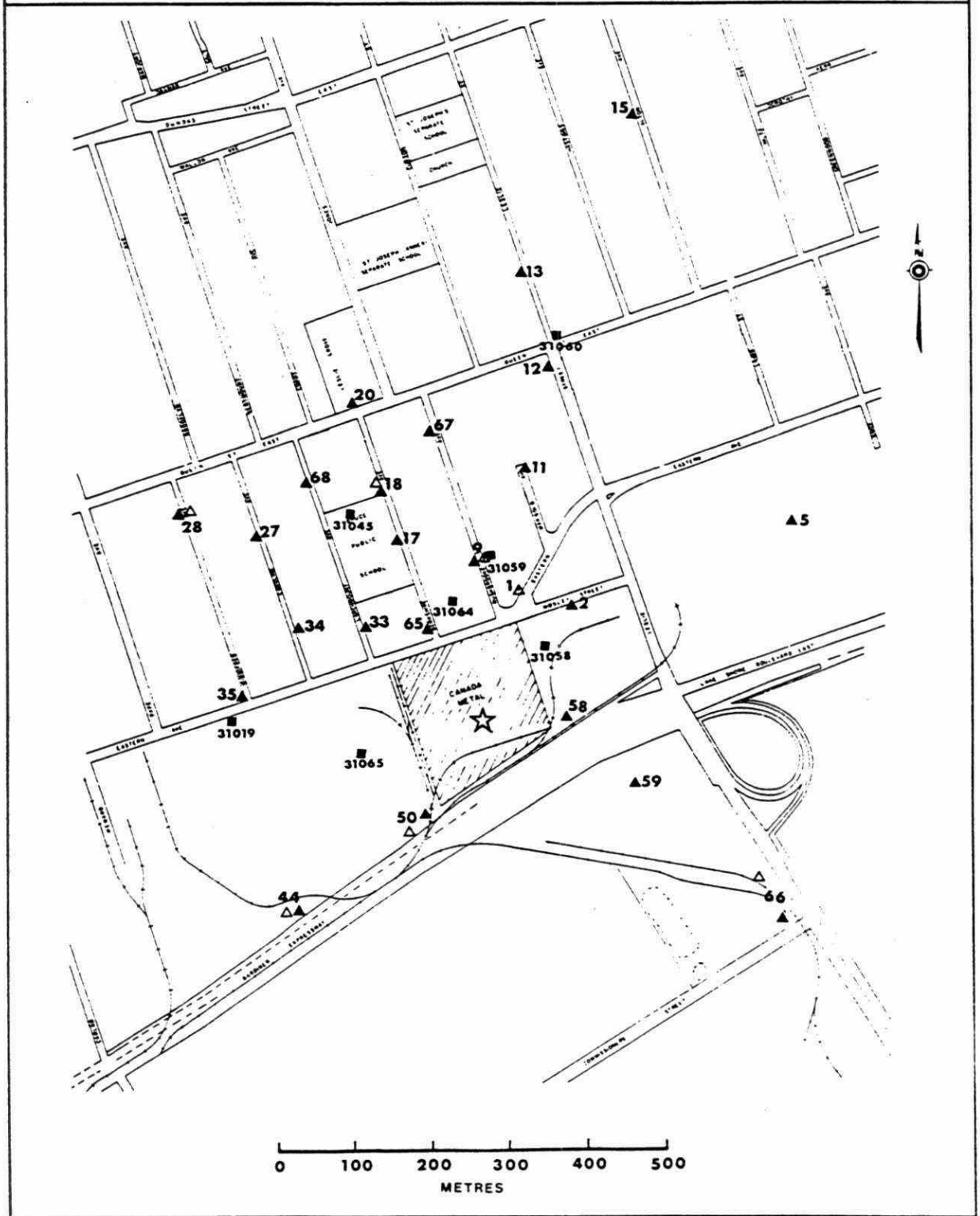
To place the details of this survey on the record, Table 1 identifies the species sampled between 1981 (since this report will discuss trends from this date) and 1991. Table 1 also notes instances where sampling of a replacement tree of the same species commenced, accompanied by a minor change in sampling location. Where sampling of a new species commenced, a minor change in location is implied.

Between 1981 and 1991, of the first 20 stations listed, three species (and locations) changes were necessary. Three other stations were relocated slightly but retained the same species. The first 20 stations only were used in temporal trend discussions since these are the only stations sampled in each year from 1981.

2.2 Sample Collection, Processing and Analysis

Sample collection consisted of cutting branches from the sides of trees facing CMC with pruning poles, removing the foliage and placing this foliage into polyethylene bags along with sample number tags. Duplicate samples from each tree were collected in 1986 through 1991.

FIGURE 1: LOCATIONS OF TREE FOLIAGE COLLECTION SITES AND AIR QUALITY MONITORING STATIONS



▲ = Tree Foliage Collection Site in 1991
△ = Previous Tree Foliage Collection Site
■ = Air Quality Monitoring Station

Table 1: Tree Species Sampled in Canada Metal Company Limited Survey, 1981 - 1991

Site	1981	1982	1983	1984	1985	1986	1987	1989	1990	1991
58	Ailanthus	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
50	Willow	---------->	---------->	---------->	---------->	---------->	---------->	---------->	Locust	---------->
65	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
59	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
2	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
33	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
9	Elm	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	Norway Maple
34	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
44	Willow	---------->	---------->	---------->	---------->	---------->	---------->	---------->	Ailanthus	---------->
35	Silver Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
11	Willow	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
18	Norway Maple	---------->	---------->	---------->	---------->	---------->	*--------->	---------->	---------->	---------->
27	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
5	Linden	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
12	Elm	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
20	Silver Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
66	Poplar	---------->	*--------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
28	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	*--------->	---------->	---------->
13	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
15	Norway Maple	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->
1	Elm	---------->	---------->	---------->	---------->	---------->	---------->	---------->	---------->	NS
17	Norway Maple	---------->	---------->	---------->	NS	---------->	---------->	---------->	---------->	---------->
67	NS	NS	NS	NS	Silver Maple	---------->	---------->	---------->	---------->	---------->
68	NS	NS	NS	NS	Norway Maple	---------->	---------->	---------->	---------->	---------->

----------> = Same tree sampled as in preceding year
*---------> = Different tree of same species in immediate vicinity sampled
NS = Sample not collected at this site

Processing involved oven drying of the foliage, removal of any non-foliage material (fruit, twigs) and grinding the sample in a rotating, stainless steel blade (Wiley™) mill to pass through a one millimetre screen.

Processed samples were submitted to the MOE Laboratory Services Branch and analyzed for lead, antimony, arsenic and cadmium using standard, documented analytical procedures.

2.3 Gerrard Street Control Area Survey

The Gerrard Street Control Area (GSCA) is located approximately 1.5 kilometres WNW of CMC. It is comprised primarily of a residential neighbourhood very similar to the one north of CMC, in terms of age and residential property characteristics. It would be subject to similar influences of general urban contaminant sources, including lead, as would the South Riverdale area. Major vehicle expressways are located at similar distances from both areas. The only major difference, for the purpose of this investigation, is the presence of a potential point source of lead emissions in the South Riverdale area, namely CMC.

The GSCA consists of 10 sampling sites. Each site has both a Norway Maple and Ailanthus tree located close together. As in the CMC survey, sampling was conducted in September of each year from 1986 to 1991 (except 1988). Single samples from each tree were collected in 1986 and 1987. Duplicate samples were collected in 1989, 1990 and 1991.

Sample collection, processing and analysis procedures were identical to those employed in the CMC survey.

3 AIR QUALITY MONITORING

As previously mentioned, The MOE Central Region maintains a network of air quality monitors. These monitors consist of suspended particulate (HiVol) samplers and dustfall jars. In some cases the two types of monitors are co-located. Lead concentrations are determined in the daily suspended particulate and monthly dustfall samples.

3.1 Suspended Particulate Sampler Locations

Between 1981 and 1991, there have been four locations within the CMC tree foliage survey area where lead in suspended particulates was determined. These locations, designated as Nos. 31045, 31058, 31064 and 31065, are indicated in Figure 1. However, only one station, No. 31058, has operated continuously between 1981 and 1991.

A fifth suspended particulate sampler, No. 31082, is located immediately west of the GSCA. It also has operated continuously between 1981 and 1991. This sampler is considered to be outside the influence of CMC.

3.2 Dustfall Sampler Locations

Between 1981 and 1991, there have been seven locations within the CMC tree foliage survey area where lead in dustfall was determined. These locations are also indicated in Figure 1. Three of these, Nos. 31019, 31059 and 31060, were active throughout this period. Two others, Nos. 31058 and 31065, failed to report data during the summer months in at least one year. The sixth, No. 31064, was discontinued in 1986. The seventh, No. 31045, was established in 1987.

An additional lead in dustfall sampler, No. 31082, is co-located with the suspended particulate sampler west of the GSCA.

4 RESULTS OF TREE FOLIAGE CONTAMINANT SURVEY

4.1 Lead in Tree Foliage

Table 2 summarizes the concentrations of lead encountered in tree foliage collected in 1981 through 1991 in the vicinity of CMC and in the GSCA. Data for samples collected before 1986 were derived from the previous Phytotoxicology Section report on CMC investigations (Ref. 2). For CMC sites sampled in 1986 through 1991, data are means of duplicate samples.

For GSCA sites sampled in the same period, data are means of all Ailanthus and Norway Maple foliage samples collected in this control area.

These data have been stratified into four groups in Table 2. The first group contains all sites that are less than 350 metres from CMC. The CMC reference point is indicated by a star in Figure 1. The second group contains sites more than 350 metres from CMC. The third group contains four sites with missing data for one or more years. The fourth group is the mean of all GSCA sites.

Foliar lead concentrations exceeded the Phytotoxicology Upper Limit of Normal (ULN) guideline (SEE APPENDIX FOR EXPLANATION OF ULN GUIDELINES) at some collection sites within 350 metres of CMC in every year from 1981 to 1991. The ULN was exceeded only at a few sites in three of the ten years at sites farther away (>350 m) from CMC. The ULN was not exceeded at the GSCA.

The lead concentration at Site 58 was 15 ug/g in 1990. In 1989 it was 210 ug/g and in 1991 it was 64 ug/g. Sample re-analysis confirmed the 1990 value. While the 1990 concentration is inconsistent, it has not been excluded since no explanation for the inconsistency is available.

Table 2: Lead Concentrations in Tree Foliage near CMC and in the GSCA - 1981 to 1991													
	Site No.	Distance (m)	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
CMC Sites	58	90	142	119	94	26	96	59	125	NR	210	15	64
< 350 m	50	150	113	119	77	175	51	71	220	NR	170	175	78
	65	150	55	61	39	47	56	29	93	NR	49	115	23
	59	200	54	25	38	38	90	43	92	NR	255	69	48
	2	200	108	100	86	160	125	150	205	NR	200	185	57
	33	220	55	46	41	50	44	35	46	NR	47	53	16
	9	240	83	122	113	255	47	85	120	NR	104	115	11
	34	285	65	32	55	38	42	32	39	NR	21	30	11
	44	330	54	63	31	36	21	21	86	NR	50	41	21
	35	345	75	67	61	78	40	51	53	NR	45	57	13
	Mean		80	75	64	90	61	57	108	NR	115	85	34
CMC Sites	11	360	33	50	39	70	28	35	33	NR	44	40	17
> 350 m	18	365	51	28	25	26	17	13	15	NR	14	13	7
	27	425	27	42	32	31	39	21	31	NR	21	16	7
	5	470	46	34	47	38	38	30	45	NR	43	43	19
	12	485	16	81	55	78	62	41	38	NR	16	39	10
	20	490	14	20	23	48	15	13	21	NR	9	9	4
	66	495	24	17	42	60	42	33	51	NR	11	12	7
	28	500	30	19	35	27	25	17	14	NR	12	10	4
	13	575	28	16	36	22	22	42	16	NR	16	24	5
	15	730	19	11	11	10	11	12	6	NR	7	13	2
	Mean		29	32	35	41	30	26	27	NR	19	22	8
CMC Sites	1	190	91	184	92	155	136	115	215	NR	235	89	NR
Incomplete	17	300	37	16	29	21	NR	19	22	NR	20	33	7
Record	67	400	NR	NR	NR	NR	18	18	23	NR	17	20	5
	68	410	NR	NR	NR	NR	17	9	11	NR	5	9	4
GSCA Mean			19	15	18	17	22	9	10	NR	6	5	3

NR = No Results Underlined data exceed the urban ULN of 60 ug/g (see Appendix)

4.2 Antimony, Arsenic and Cadmium in Tree Foliage

All tree foliage samples from the CMC area collected in 1986 through 1991 were analyzed for antimony, arsenic and cadmium because these elements are suspected of being associated with lead emitted by CMC. These data will not be tabulated or analyzed as extensively as the lead data. This is primarily because concentrations were frequently below the analytical detection limits. Consequently, it is virtually impossible to calculate mean concentrations or perform statistical analyses. Also, temporal trend analyses would be suspect because the analytical detection limits for these elements changed during this period.

Table 3 summarizes these data for 1986 through 1991. This table presents the highest and lowest concentrations encountered for these elements in the CMC survey in each year, and the sampling site where the highest concentration occurred. Because cadmium is know to be accumulated by poplar and willow species and these species were included in the CMC survey, the highest and lowest cadmium concentrations in non-accumulator and accumulator species are presented separately.

Table 3: Summary of Antimony, Arsenic and Cadmium Concentrations (ug/g) in Tree Foliage near CMC - 1986 to 1991

	Antimony			Arsenic			Cadmium non-acc			Cadmium acc		
Year	Low	High	High Site	Low	High	High Site	Low	High	High Site	Low	High	High Site
1986	0.07	2.7	1	0.14	0.75	2	0.10	0.35	2	0.75	4.0	50
1987	0.31 <	3.2	50	0.30 <	0.91 <	2	0.10	0.45	1	0.69	4.0	50
1989	0.20 DL	5.3	1	0.20 DL	1.45	1	0.10 DL	0.33 T	1	0.72	8.2	50
1990	0.20 DL	3.2	9	0.20 DL	1.20	2	0.10 DL	0.51	50	1.35	2.2	11
1991	0.20 DL	2.4	2	0.20 DL	0.95 T	2	0.10 DL	0.24 T	50	1.35	1.6	11

< = actual concentration is less than this value
DL = actual concentration is below the detection limit
T = a measurable trace amount, interpret with caution

non-acc = non-accumulator species
acc = accumulator species (willow/poplar)

The ULN guidelines are: Antimony - 0.5 ug/g, Arsenic - 2 ug/g, Cadmium - 2 ug/g. The arsenic ULN was not exceeded. The cadmium ULN was only exceeded by accumulator species. The antimony ULN was exceeded in each year.

While the antimony and arsenic data are subject to the significant constraints described above, there remained sufficient evidence of relationships between these elements and lead in foliage. These relationships will be presented and discussed later in this report.

5 LEAD IN FOLIAGE TRENDS NEAR CMC AND IN THE GSCA

The mean concentrations of lead in tree foliage from 1981 through 1991 at sites less than 350 metres from CMC, at sites more than 350 metres from CMC, and in the GSCA are graphically presented in Figure 2. It is readily apparent that tree foliage at sites located near (<350 m) CMC had substantially higher concentrations of lead than did sites farther away (>350 m). Tree foliage from the GSCA had the lowest lead concentrations.

Foliar lead concentrations in the GSCA decreased significantly in 1986 and subsequently have continued to decrease. The 1991 mean was only 3 ug/g. This trend is a direct reflection of the decrease in the use of leaded gasoline during this period. The phase-out of lead in gasoline began in the 1970s with the introduction of vehicles requiring low-lead or unleaded gasoline. In January of 1987, Canadian regulations lowered the limit of lead in gasoline from 0.77 to 0.29 ug/L. By December of 1990, sale of gasoline containing lead was prohibited.

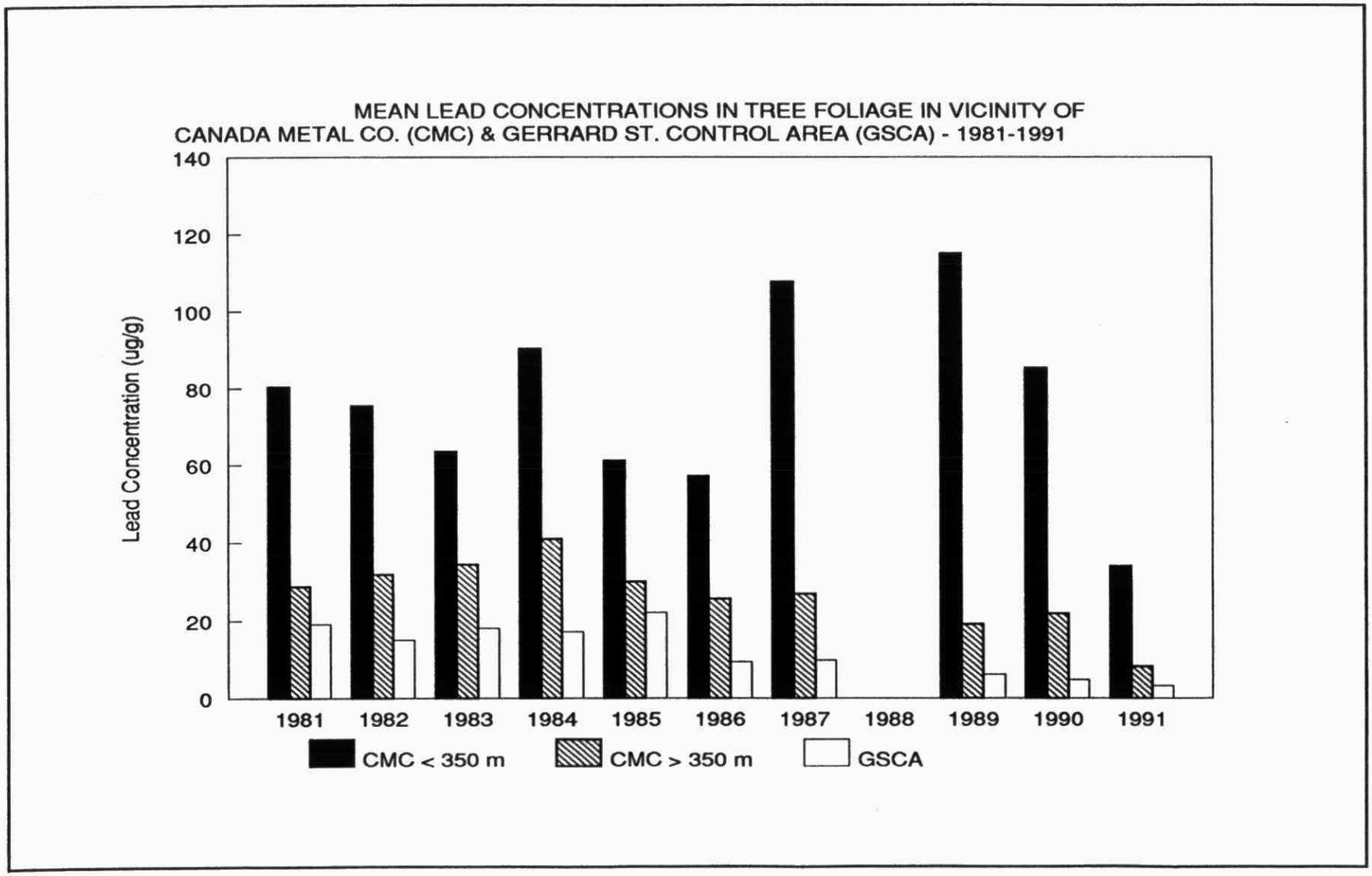
Meanwhile, foliar lead concentrations in the CMC area continued to be notably elevated during the period 1986 to 1990. Mean concentrations ranged from 57 to 115 ug/g at the <350 m sites. During this period the mean concentrations tended to be higher at these sites than in the 1981 to 1985 period when the range was from 61 to 90 ug/g.

For the >350 m sites, the 1986 to 1990 means ranged from 19 to 26 ug/g. This tended to be lower than the 1981 to 1985 means, which ranged from 29 to 41 ug/g. When all information is considered, it becomes apparent that during the period 1981 to 1990, foliar lead concentrations in the vicinity of CMC remained elevated. This is in spite of the decreasing contribution of gasoline-associated lead in the CMC area, which would have been at a similar scale to that seen in the GSCA.

In 1991 the foliar lead concentrations decreased quite dramatically. The mean for the <350 m sites was 34 ug/g compared to 8 ug/g for the >350 m sites. These concentrations were still substantially higher than the mean of 3 ug/g encountered in the GSCA. The highest 1991 individual tree concentration in the GSCA was 7 ug/g. In the CMC area the comparable concentration was 78 ug/g.

While it is not the purpose of this report to relate CMC operational changes to trends in foliar-deposited lead, the foliage data do suggest that a significant event or events within the CMC operations might have been responsible for this decrease. Sampling in 1992 should provide additional insight on this matter.

FIGURE 2:

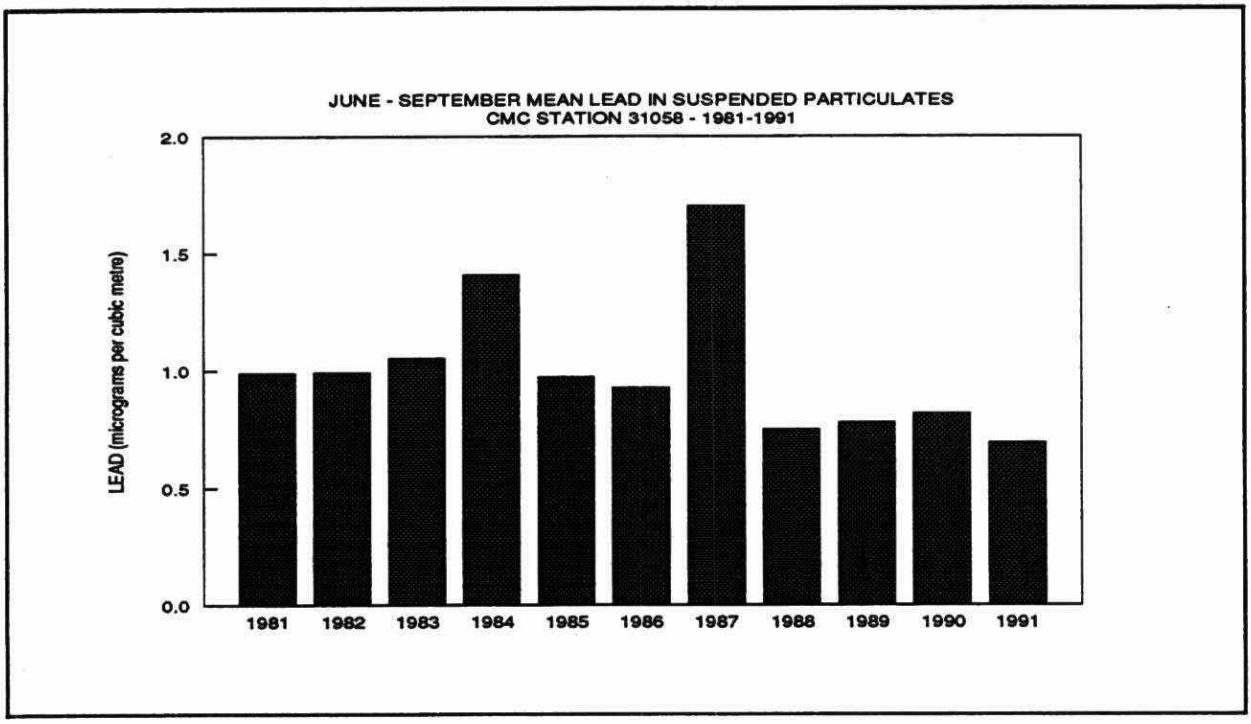

MEAN LEAD CONCENTRATIONS IN TREE FOLIAGE IN VICINITY OF
CANADA METAL CO. (CMC) & GERRARD ST. CONTROL AREA (GSCA) - 1981-1991
Lead Concentration (ug/g)
140
120
100
80
60
40
20
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
CMC < 350 m
CMC > 350 m
GSCA

6 LEAD IN SUSPENDED PARTICULATES

Data for lead in suspended particulates were obtained from the Air Quality Information System (AQUIS) database. The purpose of this report is not to interpret or evaluate these data, but merely to use them in corroborating the foliar lead data.

As was mentioned previously, only one lead-in-suspended-particulates sampler in the vicinity of CMC operated for the entire period 1981 to 1991. This station, designated No. 31058, is located very close to the CMC property (see Figure 1). The arithmetic mean of lead in suspended particulates for daily samples from the four summer months of June through September in each year are graphically represented in Figure 3. These months were chosen to coincide with the period that tree foliage would be present and therefore subject to deposition of lead.

FIGURE 3:



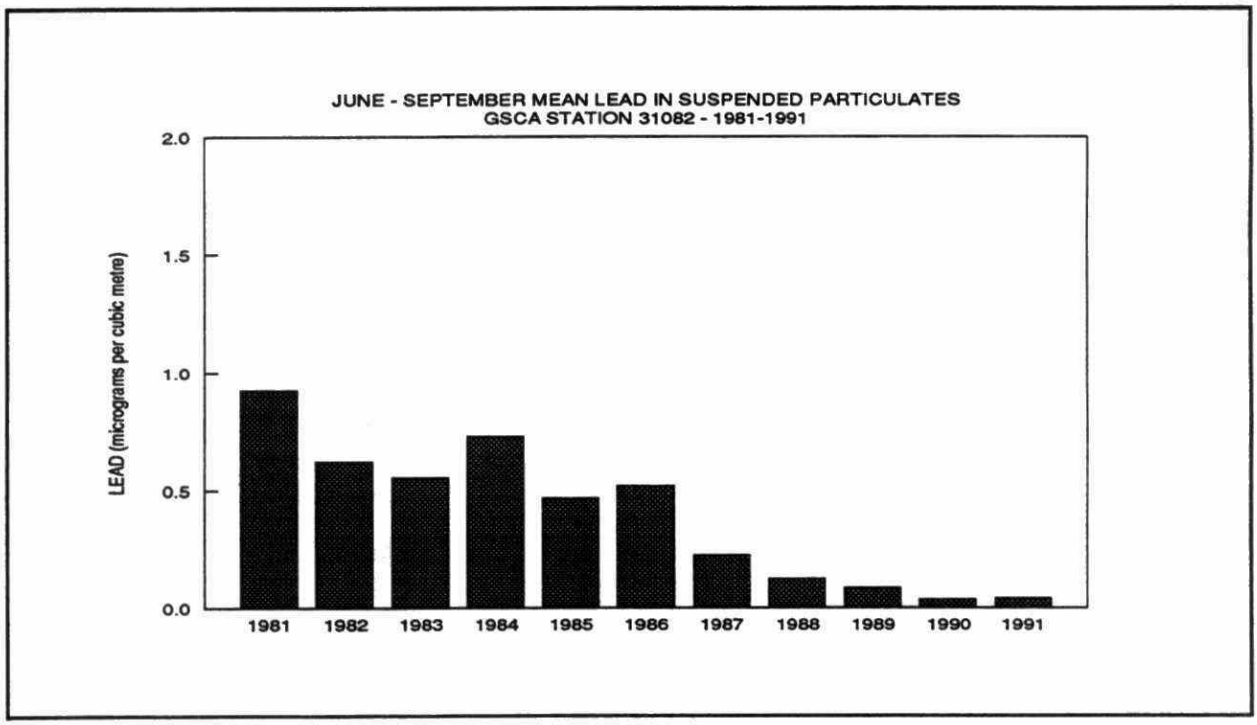
During the summer months of 1981 through 1985, the monthly suspended particulate lead concentrations ranged from 0.82 to 1.78 ug/m^3 with a mean of 1.08 ug/m^3. During the next five summers (1986 to 1990) the range was 0.45 to 2.3 ug/m^3 with a mean of 0.99 ug/m^3. During both five year periods there was one year, 1984 and 1987, respectively, where ambient air lead was notably higher. During the summer of 1991, the monthly suspended particulate lead concentration range was 0.27 to 1.1 ug/m^3 with a mean

of 0.69 ug/m^3. The 1991 mean is the lowest to date but is still quite similar to the concentrations measured in 1988, 1989 and 1990.

The Ambient Air Quality Criterion for suspended particulate lead is 3 ug/m^3, determined as the arithmetic mean of daily samples collected in a 30 day period. This criterion has not been exceeded in any of the summer months from 1981 to 1991.

The suspended particulate lead sampler near the GSCA, designated No. 31082, has also operated continuously. The same summer month averages are represented in Figure 4. A substantial decrease in ambient air lead was registered in 1987 and again in 1990. These decreases are in phase with the reduction and the elimination of lead in gasoline.

FIGURE 4:



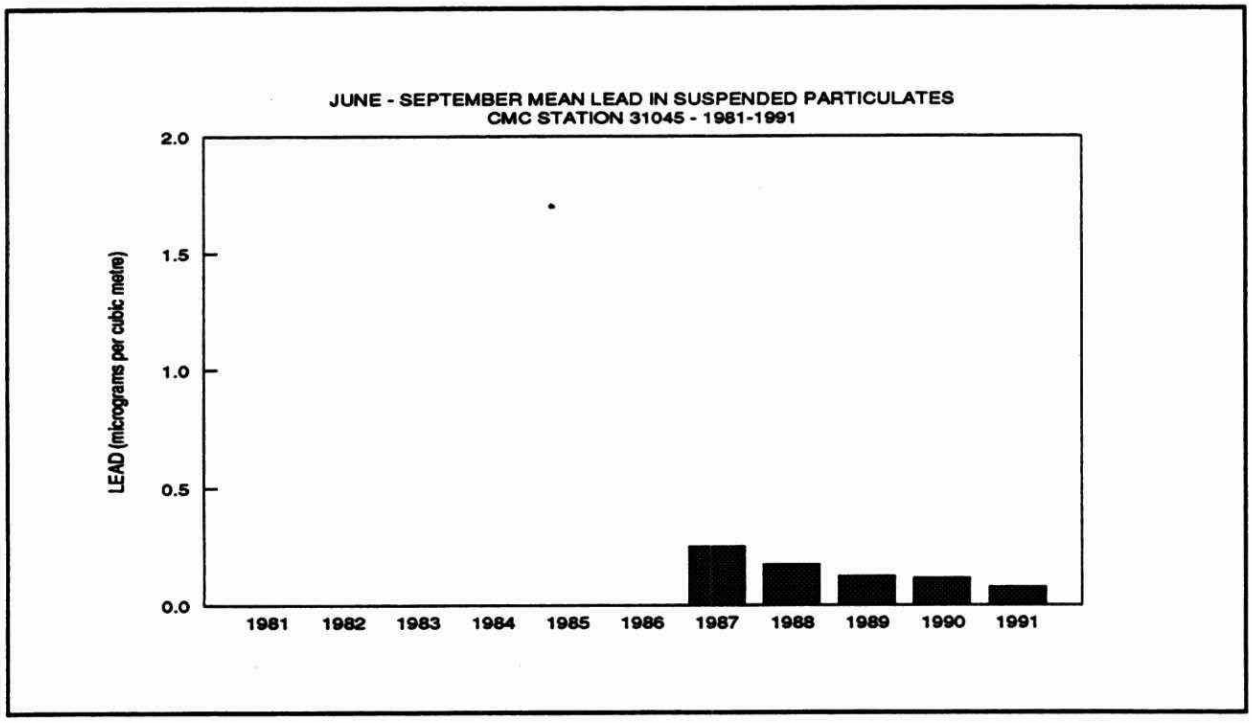
A comparison of Figure 3 and 4 shows that lead in suspended particulates near CMC, specifically at Station 31058, is considerably higher than at Station 31082 in the GSCA. This points to CMC as a continuing source of lead emissions.

There is one additional air quality station indicated in Figure 1 where suspended particulate lead is currently (as of 1991) measured. Station 31045 began operating in October, 1986. This station deserves discussion since the magnitude and trend of suspended particulate lead at this station is in contrast to Station 31058. Station 31045 is at a much greater distance from CMC

than Station 31058. Consequently, concentrations are considerably lower at Station 31045. The most distinctive feature at Station 31045 is the steady decline in suspended particulate lead between 1987 and 1991 (Figure 5).

When this trend is compared to that seen at Station 31082, near the GSCA, a strong similarity is observed. This suggests that Station 31045 data are also reflecting the decline of lead in gasoline, although the notably higher concentrations point to at least some influence by another source.

FIGURE 5:

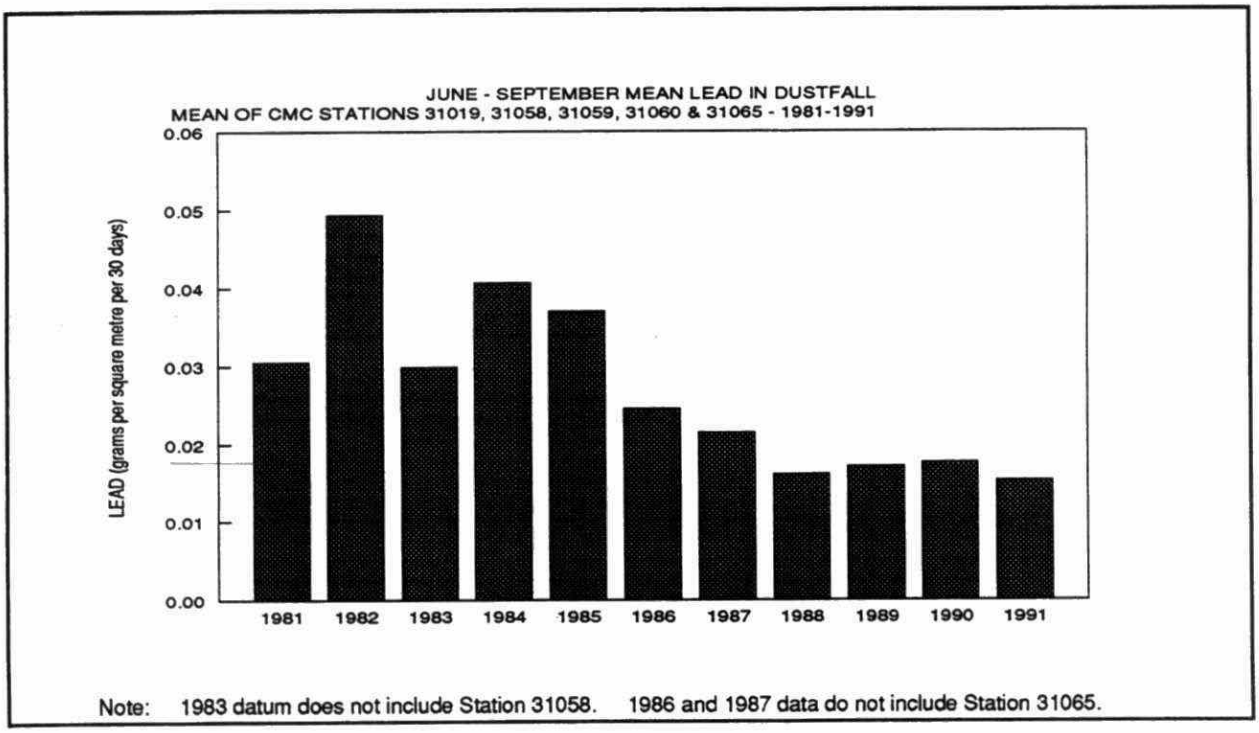


7 LEAD IN DUSTFALL

Lead in dustfall data were likewise obtained from the AQUIS database. As was mentioned in Section 3.2, there were seven stations measuring lead in dustfall in the vicinity of CMC between 1981 and 1991. However, two of these (Nos. 31064 and 31045) were either discontinued or only operated for a short period. Of the remaining five, only three (Nos. 31019, 31059 and 31060) reported data for at least two of the four summer months, June through September, for each year. The remaining stations (Nos. 31058 and 31065) did not report lead in dustfall during the summer months in one or two of the years during the period 1981 to 1991.

In spite of the data gaps for these last two stations, means of lead in dustfall for the five most frequently reporting CMC dustfall stations were calculated. Only data from the four summer months were used. These means are graphically represented in Figure 6. Because the missing data are from the two stations located closest to CMC, it is reasonable to assume that the 1983, 1986 and 1987 five-station means of lead in dustfall are underestimated in Figure 6.

FIGURE 6:

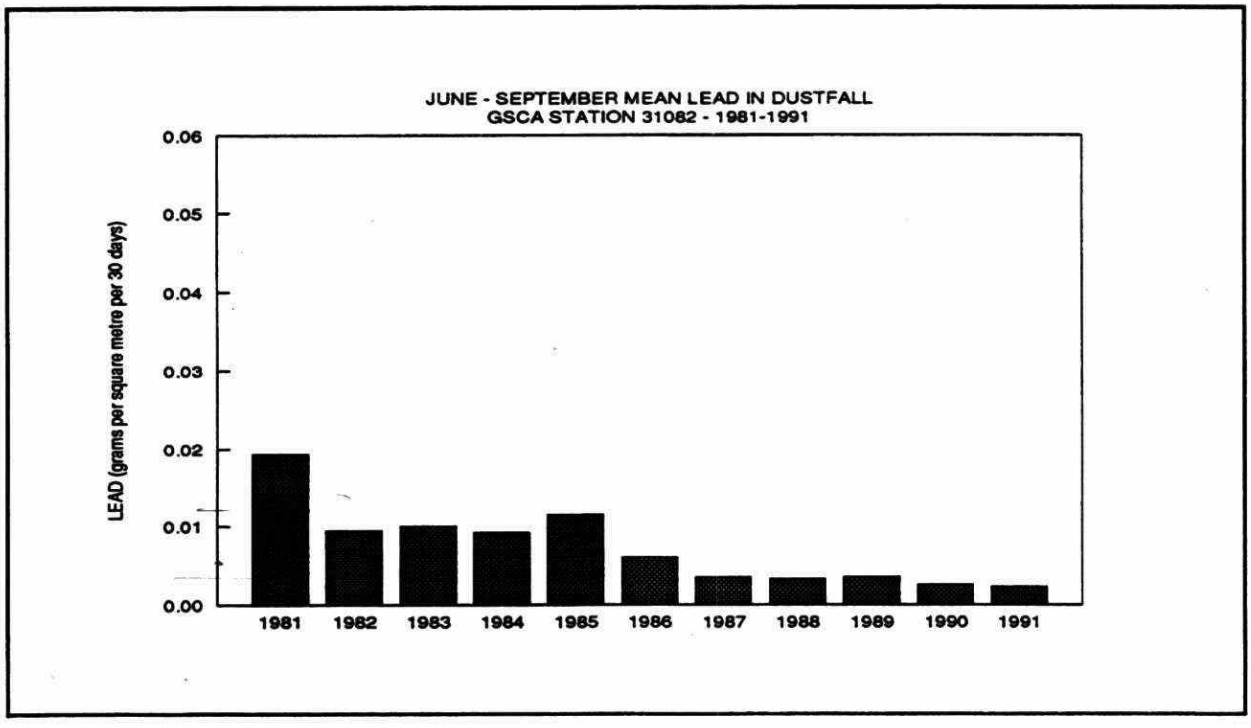


Based on this assumption is appears that lead in dustfall declined in 1988 to levels that were about one half of what was present in the early 1980's. Since 1988, lead in dustfall has been constant in the vicinity of CMC.

The Ambient Air Quality Criterion for lead in dustfall is 0.1 gram per square metre per 30 days ($g/m^2/30$ d). According to the AQUIS, this criterion was not exceeded during the summer months of 1986 through 1991 at any of the five CMC stations. During the summer months of 1981 through 1985, the criterion was exceeded four times at these stations.

The dustfall lead near CMC can be compared to what was encountered at Station 31082 near the GSCA. The summer month means for this station are represented in Figure 7. Here a decline was registered in 1986, and maintained and enhanced since then. This trend closely resembles the suspended particulate lead trend at the same station. The reduction in the use of lead in gasoline is, therefore, also reflected in the lead in dustfall data for this station.

FIGURE 7:



Comparing Figures 6 and 7 demonstrates that the amount of lead being deposited in the vicinity of CMC has been and remains substantially higher than in the GSCA. In 1991, the summer month mean of the five CMC stations was 0.015 $g/m^2/30$ d. At the GSCA Station 31082 the summer month mean was 0.002 $g/m^2/30$ d, or an order-of-magnitude lower.

Clearly, CMC continues to be a source of lead to the surrounding neighbourhood: however, the Ambient Air Quality Criteria are not being exceeded. Whereas the primary source of lead in urban areas, i.e. gasoline, has been eliminated, the South Riverdale neighbourhood near CMC continues to be influenced by lead emissions from this company.

Urban soil is acknowledged to have higher background lead concentrations, primarily due to gasoline lead sources. The ULN guideline for urban soil is 500 ug/g compared to 150 ug/g for rural soil. If CMC continues to emit lead, concentrations in the remediated soil will increase over time. Some evidence of this was reported in a Phytotoxicology Section investigation designed to verify the soil remediation project (Ref. 1).

8 LEAD IN TREE FOLIAGE AND AIR QUALITY MEASUREMENTS

A comparison of the lead concentrations detected in tree foliage with lead measured in suspended particulates and dustfall must be prefaced with certain caveats. The foremost is a reminder that the air quality monitors are not co-located with the tree foliage sites.

Another consideration is the nature of the three monitor types and their capabilities to intercept and retain contaminants. Suspended particulate samplers collect particles that are suspended in an air mass. Dustfall collectors capture larger particles that settle, under gravitational forces, close to their source of origin. Tree foliage would intercept particles that impact on their surfaces. Elements in these particulates would be partially absorbed by the leaf tissue. Although rain could wash off some of these particles or leach out some of the previously absorbed substances.

Consequently, the only valid comparisons of foliage and air quality measurements are of general trends in lead concentrations, and to a limited extent, the magnitude of deviations from these trends.

The first comparison will be of the suspended particulate and dustfall lead data, as reflected in Figures 3 and 6 respectively. Both types of monitors tended to register lower levels of lead in 1988 and later. However, tree foliage concentrations remained high. Only in 1991, did tree foliage concentrations decrease to a record low mean.

A closer examination of suspended particulate lead at Station 31058 (Figure 3) and mean foliar lead for the <350 m sites (Figure 2) shows concomitant peaks occurring in 1984 and 1987. Foliar lead at these sites remained high in 1989 and 1990 while suspended particulate and dustfall lead levelled out at concentrations that were noticeably lower than those of 1981 to 1987.

Offering explanations for the loss of agreement between air quality measurements of lead and foliar lead concentrations would be, at best, speculative. The only recourse, having made this observation, is to continue to monitor using all methods.

Another area where air quality and foliage lead measurements can be compared is in the GSCA. As was discussed previously, suspended particulate and dustfall lead in the GSCA reflected the decline in use of lead as a gasoline additive. The GSCA foliage registered a similar decline in 1986 and this decline has continued to 1991. This is compelling evidence of the value of tree foliage chemistry in evaluating the presence of a contaminant such as lead in the air.

9 LEAD VERSUS ANTIMONY AND ARSENIC IN TREE FOLIAGE

To assess the relationships between foliar lead concentrations with those of antimony and arsenic, plots of concentrations determined in each individual foliage sample collected in the CMC area between 1986 and 1991 were generated. These plots are presented in Figures 8 and 9.

FIGURE 8:

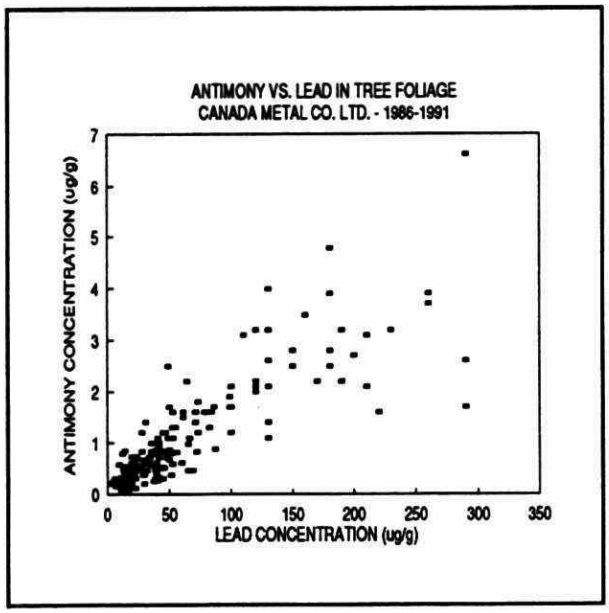
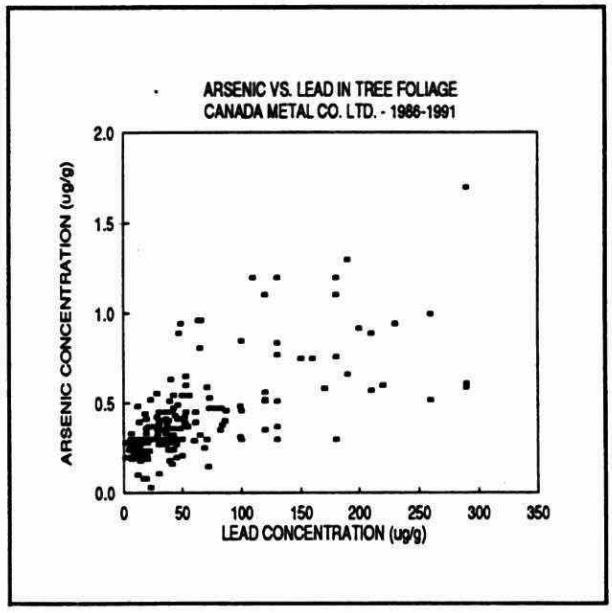


FIGURE 9:



These figures clearly indicate the fact that foliar antimony and arsenic are present in higher concentrations in samples that have high concentrations of lead. Antimony is alloyed with lead in the manufacture of plates for lead-acid batteries. These plates are the primary source of lead for the CMC processes. The nature of the source of arsenic has not been determined.

10 SUMMARY AND CONCLUSIONS

Between 1986 and 1991 (except 1988), the Phytotoxicolgy Section collected tree foliage samples from the vicinity of Canada Metal Company (CMC), and from the Gerrard Street Control Area (GSCA). These samples were analyzed for lead and other contaminants. The data revealed ongoing contamination of tree foliage in the vicinity of CMC. Tree foliage from the GSCA reflected the discontinued use of lead in gasoline, with concentrations declining. Up to 1990, lead in tree foliage from the CMC area remained elevated and failed to reveal any declining trend. Only in 1991 did CMC area foliar lead concentrations decline to a record low. However, this record low is still substantially higher than GSCA concentrations.

Lead in suspended particulates and dustfall data were reviewed to determine if they could corroborate the trends in the CMC and GSCA foliar lead data. The air quality data from CMC area stations indicated marginally lower lead levels between 1988 and 1991, when compared to those of the early to mid 1980's. GSCA air quality data revealed substantial and continuing decline in ambient air lead, reflecting, as did the foliar data, the removal of lead in gasoline.

While CMC area air quality (specifically suspended particulate) and foliar lead data tended to agree until 1987, this agreement appears to fail since then. While ambient air lead is lower, foliar lead remained at early 1980s levels through 1990.

A comparison of foliar lead concentrations with those of antimony and arsenic, revealed that the latter elements are also associated with lead deposition in the CMC area.

The evidence provided by the foliage samples and air quality measurements suggest that Canada Metal Company continues to be a source of lead to the South Riverdale neighbourhood. While ambient air lead as well as foliar lead did register lower concentrations recently, these concentrations are still considerably higher than those now encountered in the GSCA.

Given the substantial effort extended to remediate the soil in the South Riverdale area, a further analysis of current emissions and rates of deposition of lead attributable to CMC is warranted to ensure that the remediation efforts are not jeopardized.

11 REFERFENCES

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2. Rinne, R. J., 1986, *Contamination of Vegetation and Soil by Lead and Other Elements in the Vicinity of Canada Metal Company, Eastern Avenue, Toronto - 1983, 1984, 1985*, Ministry of the Environment, Air Resources Branch, ARB-064-86-Phyto, March, 1986

3. SENES, 1991, *A review of the Processes and Practices at the Canada Metal Company, Toronto, Ontario*, SENES Consultants Ltd., January, 1991

APPENDIX

Derivation and Significance of the MOE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: Ontario Ministry of the Environment 1992, *Phytotoxicology Field Investigation Manual*). Chemical analyses were conducted by the MOE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.